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Exploring iPad Technology Integration in a Middle Grades Science Classroom: M-TPACK as a Framework for Developing Students' Science and Digital Literacies

Nance S. Wilson, Ph.D.
Associate Professor
Literacy Department
School of Education
SUNY Cortland
P.O. Box 2000
Cortland, NY 13045-0900
(407) 451-5205

Vicky I. Zygouris-Coe, Ph.D.
Professor
University of Central Florida
College of Education & Human Performance
School of Teaching, Learning, & Leadership
P.O. Box 161250
Orlando, FL 32816-1250
(407) 823-0386

Victoria Cardullo, Ed.D.
Assistant Professor Reading Department
College of Education
Auburn University
5070 Haley Center
Auburn, Al. 36849
(334) 844-6882

Lourdes Smith, M.Ed
Reading Education Doctoral Student
University of Central Florida
College of Education and Human Performance
Orlando, FL 32816-1250
(407) 489-7012

Abstract

The affordances of technology present both opportunities and challenges for building students' disciplinary literacy practices. Science literacy, specifically, requires that students comprehend texts that have technical language, concepts, and topics removed from their everyday life experiences. This study explored the development of one teacher on the M-TPACK (Metacognitive, Technological, Pedagogical and Content Knowledge) (Wilson, Zygouris-Coe, Cardullo, & Fong, 2013) framework as she integrated iPads into classroom instruction to increase students' science literacy knowledge and practices.

Exploring iPad Technology Integration in a Middle Grades Science Classroom: M-TPACK as a Framework for Developing Students' Science and Digital Literacies

Despite the fact that technology is placed in K-12 classrooms across the U.S., the research exploring the impact of technology on teaching and learning is still relatively new (e.g., Apple, Inc., 2014; Karsenti & Flevez, 2013). Technology integration into the general K-12 curricula raises many questions about emerging pedagogies and technologies. Since some view technology as a panacea, many districts and schools are investing heavily in devices and technology systems. However, technology has been viewed as an add-on to existing pedagogical models. In the presence of global and federal initiatives for best 21st century preparation of all students, we cannot afford to ignore the need for instructional frameworks, teacher professional development, and ways to integrate technology so it builds student learning. We must recognize that technology causes a disruption in how we read, write, and communicate; thus, there is a need to learn how to harness the potential of technology to for content and literacy learning.

The iPad is a handheld device that provides opportunities for mobile learning while also requiring a distinct set of literacy practices. These practices include the digital literacy of reading the iPad screen, choosing Apps, knowing how to highlight and share in an e-book, and more. A teacher who successfully implements iPads utilizes metacognitive teaching to orchestrate her knowledge of pedagogy, students, content, and technology. She executes her instruction based upon her knowledge and her disposition to be an adaptive reflective practitioner.

When teachers decide to integrate technology such as the iPad into their classroom, it is imperative that they use a pedagogical framework that supports knowledge integration and metacognitive teaching and learning. Our framework, known as the Metacognitive, Technological, Pedagogical and Content Knowledge (M-TPACK) (Wilson, Zygouris-Coe, Cardullo, & Fong, 2013), requires that the teacher has knowledge of the technology, curriculum, students, and pedagogy to successfully implement this knowledge in an adaptive/metacognitive manner. This framework is key because it requires that teachers use their knowledge to engage in metacognitive thinking to be strategic as they engage in instruction, solve problems, and adjust instruction to meet students' individual needs rather than just assume that a teacher's knowledge alone will lead to successful implementation of the iPad for learning.

Literacy learning occurs in every content area. For the purpose of this study, we use the term disciplinary literacy when referring to discipline specific literacy. Disciplinary literacy refers to the reading, writing, discourse, listening, and habits of mind that are specific to each discipline (Shanahan & Shanahan, 2012; Zygouris-Coe, 2015). Disciplinary literacy also addresses the lack of success with general content area literacy in developing students' advanced literacy knowledge skills and content knowledge (Phelps, 2005, Shanahan & Shanahan, 2008; Zygouris-Coe, 2015). The specialized discourse of each content area requires advanced literacy instruction that is focused on the literacy knowledge, skills, strategies, and dispositions of that specific discipline.

Science literacy requires that students read and comprehend texts that are filled with technical language, concepts, and topics removed from their everyday life experiences (Fang & Schleppegrell, 2010; Shanahan & Shanahan, 2008). Scientists ask a lot of questions about their world, although science in schools is often thought of as learning facts, and students need to see science learning as a way to make sense of their world (Zygouris-Coe, 2015).

Science teachers can use technology in a variety of ways (e.g., to take lab notes, explore data and information about different phenomena, virtual dissections labs) to support and extend students' science and literacy learning and help students acquire disciplinary literacies unique to science (Castek & Beach, 2013). Thus, in a classroom utilizing iPads the teacher must instruct students in science disciplinary literacy and digital literacy.

Digital literacy refers to the ability to use digital technology, tools, or networks to make meaning from, and with, texts in multiple formats and form a variety of sources, to locate, interpret, create, evaluate, apply, and share knowledge (about texts, data, images) from and across digital forms and contexts. Digital literacy is key to preparing students for the 21st century. It assures that students know how to learn from the digital technology tools that are part of our daily lives.

This case study explored the practices of one teacher through the lens of the M-TPACK (Metacognitive, Technological, Pedagogical and Content Knowledge) (Wilson, Zygouris-Coe, Cardullo, & Fong, 2013) framework as she integrated iPads into her science classrooms to increase students' science literacy knowledge and practice. In this paper, we use the term "practices" to refer to how this teacher combined devices, content, skills, pedagogy, and context, to engage students in science learning. The purpose of this study was to understand the teacher's knowledge and dispositions as a metacognitive teacher in the context of iPad integration in her classroom for science and literacy purposes. Data sources included teacher interviews, classroom observations, and one of the researcher's and the participating teacher's field notes.

Perspective/Theoretical Framework

M-TPACK. Integrating iPads into the classroom requires more than simply passing out the devices and giving teachers and students access to Applications (Apps). Instead, it requires much careful planning, alignment with educational and content standards, and coaching and professional development that builds teachers' Metacognitive Technological Pedagogical Content Knowledge (M-TPACK) (Wilson, Zygouris-Coe, Cardullo, & Fong, 2013).

M-TPACK is different from other theories on technology integration, such as Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006), because it focuses not just on the teacher's knowledge but her dispositions and decision making process when engaging in instruction using technology. M-TPACK is key to successful implementation of technology because it acknowledges teachers' knowledge of students, pedagogy, content, and technology while centering the focus on the teacher's metacognitive decision-making skills and dispositions. The metacognitive teacher responds immediately to unanticipated situations by making conscious and deliberate decisions utilizing her knowledge and dispositions (Duffy, Miller, Parsons & Meloth, 2009; Lin, Schwartz & Hatano, 2005). One example of the metacognitive teacher in action can be found in Lin (2001) who learned that the implementation of new technology into her teaching forced her to adopt new teaching routines from the presentation of material to how she had students working on math problems. A metacognitive teacher is one who recognizes the need to adapt instruction with the implementation of new technology to move beyond using the technology as a substitute for paper and pencil tasks.

SAMR. *Substitution, Augmentation, Modification, Redefinition* model (SAMR) (Puentedura, 2006) can provide a framework for technology as teachers develop tasks to reach learning goals and objectives for course work. The SAMR model is further divided into two domains: transformation and enhancement. Enhancement includes the levels of *substitution* and *augmentation*, whereas the transformation stage is inclusive of *modification* and *redefinition* (Cardullo & Burton, 2015). The SAMR Model (Puentedura, 2006) is a useful tool for teachers and researchers to help them understand the levels of integration of emerging technologies being used in the classroom (Romrell, Kidder, & Wood, 2014). The SAMR model (Puentedura, 2006) illustrates how teachers process a task when adopting educational technology. In the substitution stage, there really is no functional change in the implementation of learning and technology; it is simply substituting one for another. In the augmentation stage, technology acts as direct substitution of the task, with some functional improvement. In the modification stage, technology allows for the significant redesign of the task and in the redefinition stage technology allows for the creation of a new task, a task previously unconceivable (Puentedura, 2006). The iPad is a device that is mobile and shares some of the capabilities of a full computer. The Applications in the iPad give it the power of a traditional laptop where its size puts it in the realm of mobile technologies.

Research on the use of mobile applications for academic purposes have demonstrated that effective and consistent use of particular applications will improve academic achievement (McClanahan, 2012; Perkins, Hamm, Pamplin, Morris, & McKelvain, 2011). This and other related research, along with the promise of less expensive and updated e-books, hands-on personalized experiences, and device adaptive capabilities such as speech recognition and text to speech (D'Orio, 2011) have resulted in widespread adoption of iPads into K-20 classrooms. Additionally, iPad integration has demonstrated a positive impact on learning through active engagement, increased time for projects, improved digital literacy, and digital citizenship (Chou, Block, & Jesness, 2012). The use of the iPad as a tool for content delivery offers new learning spaces (Shih & Mills, 2007) and has the potential to change the culture of teaching and learning.

Disciplinary science reading. In order to learn effectively in the disciplines, students need instruction that will provide them with effective strategies for comprehending science texts and for applying science knowledge (Craig & Yore, 1995; Fang, 2005). The integration of iPads in science literacy instruction can provide authentic and engaging experiences for students as they interact with the iPad for academic learning. The use of the iPad also provides a tool for aligning science content to the requirements of the Common Core State Standards (CCSS), which view media and technology as an integral part of college and career readiness (NGA & CCSO, 2010). Students' use of iPads built upon their digital literacies as they employed digital tools and resources to make sense of science content, build knowledge, and share ideas (Kiili, Mäkinen, & Coiro, 2013). We believe that effective integration of technology in the classroom requires the teacher to make metacognitive curricular, instructional, and pedagogical decisions. This case study is an in-depth examination of a fifth to eighth grade science teacher's journey from the initial adoption of a class set of iPads through her stages of implementation and redefinition of her instruction through the lens of the M-TPACK and SAMR models.

Methodology

This study took place during the course of a single school year. It was the teacher's initial adoption and implementation of iPads to teach fifth to eighth grade science. The teacher volunteered to participate in the study in exchange for additional support regarding the iPad. Prior to the study the teacher had no experience with iPads and was adopting only because, it was part of her teaching assignment. The school had purchased a class set of iPads for the teacher to use and expected regular implementation of the technology. The school was a K-8 small high socio-economic school located in a Midwestern suburb. The teacher had a Bachelor's degree in science education and a Master's degree in curriculum and instruction. She also had 20 years of teaching experience with 11 years in self-contained upper elementary classes and nine as a sixth, seventh, and eighth grade science teacher. The students in this study were in grades five to eight. There were a total of 70 students in the four grade levels.

Data collection. Data were collected throughout the course of the school year through a variety of techniques. The teacher and researcher met on a weekly basis to discuss iPad usage and experiences, science literacy techniques, and the incorporation of the two. Throughout these meetings there were four formal interviews regarding iPad adoption and implementation as a tool for building disciplinary science literacy. The researcher observed the teacher and collected artifacts throughout the course of the year. The classroom teacher kept a journal of teaching experiences and aligned them with the artifacts she chose to include in the study. The artifacts were organized around the CCSS for the teaching of literacy in science and technical subjects. The data was collected through a combination of field notes, audio recordings of teaching and weekly meetings, email correspondence, and artifacts such as lesson plans and student work samples.

Data analysis. Data was analyzed in a recursive manner using both grounded theory and constant comparison (Straus & Corbin, 1998). This approach of data collection allowed for the data to lead to weekly meetings with the teacher to assure that coaching conversations were based on helping the teacher build students disciplinary and digital science literacy. After three of the four formal interviews, researchers reviewed the data as a whole to analyze how the teacher was successfully integrating the iPad as a tool for disciplinary science literacy. As data was collected, we were able to generate emerging conclusions, which, in turn, drove subsequent observations and interviews. Tentative conclusions developed through a process of constant comparison as the emerging themes were checked and compared with the incoming data and allowed to evolve with the new information while remaining true to the previous data.

The second stage of data analysis allowed for an aggregation of instances (Stake, 1995) to determine themes and findings based on Puentedura's (2009) SAMR model and Wilson, Zygouris-Coe, Cardullo, & Fong's (2013) Metacognitive Technological Pedagogical Content Knowledge (M-TPACK) frameworks. The second stage of analysis led to the creation of two codebooks. The first codebook went through two revisions. The first version was established by a review of the characteristics of each area of the M-TPACK model. The codebook was then applied to the data by three of the researchers. After this initial analysis, inter-rater reliability was only 90%. Therefore, there was a revision of the codebook based on conversations around ten percent of the data. The data was recoded using the revised codebook with 97.4% inter-rater reliability (See Table 1 for codebook 1).

Table 1

Codebook 1

<table>
<tr><th>Codebook 1 (90% inter-rater reliability)</th><th>Codebook 1 Revised (97.4% inter-rater reliability)</th></tr>
<tr><td>General Use of technology
Knowledge of Content
Knowledge of Technology
• Internet Use
• Google Docs
• iPad Specific
Knowledge of Pedagogy
• Classroom management
• General Reading
• Use of video/multimodal literacy
Knowledge of Student
• Student knowledge of iPad use
Metacognitive Teacher
• Decision-Making about technology
• Decision-Making about adaptive Instruction</td><td>General Use of technology
• Discipline Specific Ways to use the iPads
• Further/extended use of technology due to iPad
Knowledge of Content
Knowledge of Technology
• Internet Use
• iPad Specific
Knowledge of Pedagogy
• Modeling
• Classroom management
• General Reading
• Use of video/multimodal literacy
Knowledge of Student
• Student Learning as a result of technology
• Student knowledge of iPad use

Metacognitive Teacher
• Interaction of pedagogical, content, student and technology knowledge
• Decision-Making about technology
    o How technology is changing instruction
• Decision-Making about adaptive Instruction</td></tr>
</table>

The data was also coded using a second codebook by two researchers (see Table 2 for Codebook 2). The second codebook was developed using the framework of the SAMR model (2009) for analysis of instances using the open coding process. Open coding is the process breaking down, examining, comparing, conceptualizing, and categorizing data (Strauss & Corbin, 1998). The categories and operational definitions were defined for the organization of the final coding. Substitution was defined as using the iPad as a direct tool to substitute paper and pencil tasks with no functional change to the task. Augmentation was identified when the iPad was used as a direct tool substitute with no improvement to the specific task. Modification was identified when technology allowed for significant task redesign. Finally, redefinition was used as a code when the iPad allowed for the creation of new tasks that were previously inconceivable without the technology.

Table 2

Codebook 2

Code Name	Operational Definition	Characteristics
	SAMR Model	
Substitution	Technology acts as direct tool substitute with no functional improvement.	Notability: note taking, writing, summarizing
Augmentation	Technology acts as direct tool substitute with functional improvement.	Creating files, web search, electronic graphing, Notability for drawing, quizlet, shared information using Google drive
Modification	Technology allows for significant task redesign.	Video recording, take notes, drew diagrams, shared notes and responded to questions electronically
Redefinition	Technology allows for the creation of new tasks that were previously inconceivable.	Virtual labs, i-movie, Webquest, Prezi, electronic poster presentations, brochures

The utilization of the two codebooks provided a window into both the teacher's metacognitive pedagogical content knowledge and the level of iPad integration in her science classroom. The results are described first by the findings from each codebook and then through a compilation of the data to illustrate how disciplinary and digital science literacy instruction was achieved. Throughout each analysis, notice how the primary tool used by the teacher was the application Notability for students to record lab reports and take notes in class. This application allows for typed and handwritten note taking, sketching, audio recording, taking pictures, annotations of PDFs, and the development of charts to name a few functions.

M-TPACK: Integration of knowledge required teacher adaptation

The following section will describe the analysis of the data based upon the M-TPACK framework. Figure 1 provides a visual of the framework and how the data was analyzed.

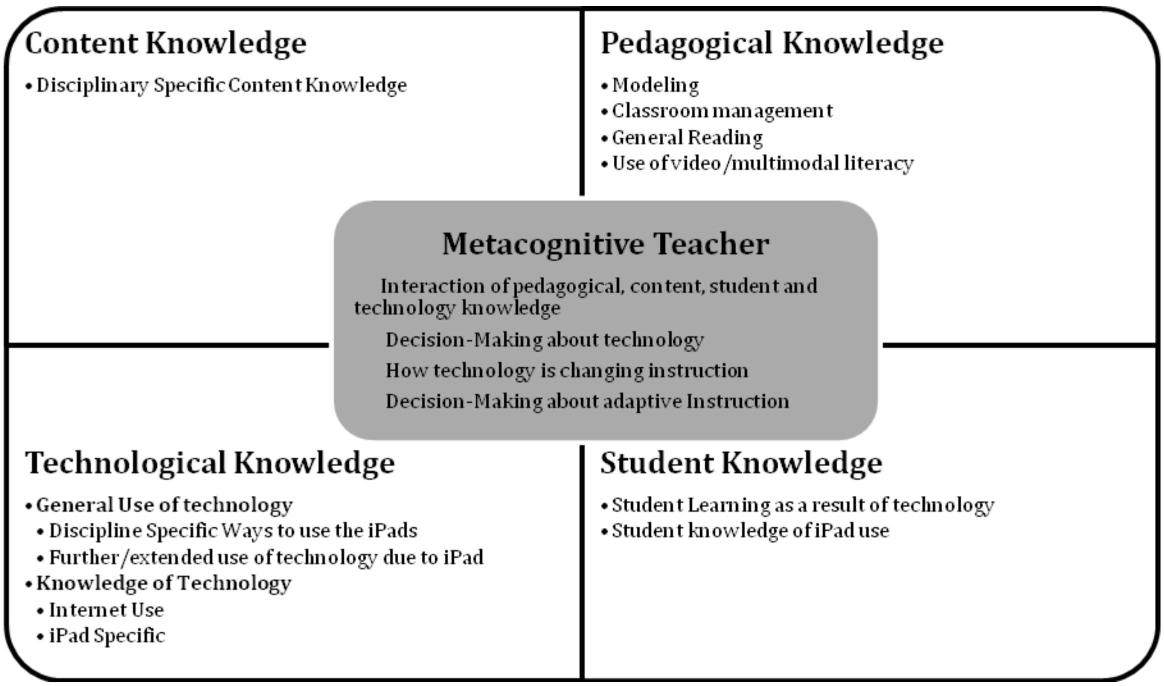

Figure 1. M-TPACK This figure illustrates the elements of the M-TPACK framework.

Pedagogical knowledge. Integration of iPads in the classroom presented new pedagogical challenges for the teacher. The use of iPads required the creation of new routines, such as charging iPads, signing in and out of accounts, location, access, and use of iPads. These routines took time to develop and required revision as student use of the iPads increased throughout the school year. The pedagogical shifts in the classroom management were short term, but key to iPad implementation in the first quarter of the school year.

When discussing the preparation and use of the iPad and Notability in the classroom, the teacher reflected on both the pedagogy and required routines. When discussing some aspects of developing routines, the teacher said, “I finally figured out too that I need to assign them each a number for the iPad and keyboard. I just went down the list. You are responsible for charging number 1” (iPad meeting, September 19, 2013). She continued, later noting, “we lost one today (keyboard) but we found it because N was absent and he didn't know his number. He just grabbed one” (iPad meeting, September 19, 2013). Although seemingly minor, these types of steps and situations are needed to ensure good time-management and routine consistency when using technology. This is an important part of the early stages of implementation of new technologies in the classroom.

Modeling and providing examples also offer a way to enhance the experience for learners. The teacher noted, “I have been doing a lot of modeling with them...Like today with the 8th grade. I said this is what I expect when you are on your own. So they have an example and say this is how she wants me to write it. This is what she wants me to do” (iPad meeting, September 19, 2013). This comment demonstrates the teacher’s understanding regarding the importance of modeling how new technologies can be used along with the providing examples for the students resulting in desired expectations for the product.

In addition to supporting students by modeling, the teacher began to understand that creating models and examples may not be enough for assisting learners with new technology. The teacher reflected on this notion when she said, “you know like I went through and did the whole Notability thing. I did an example or whatever, to see what kinks, until you really do it, some of those kinks don’t come through. You have to think ahead. You have to do it with the class once to find some problems. You can't think through every challenge" (iPad Meeting, September 19, 2013). Building technology examples in isolation, without others' input, may lead to an incomplete picture of what is needed to support learners. Understanding that practicing new technologies with students can support pedagogy is another piece to the puzzle for good implementation. This reflects the need to provide time to develop a pedagogical understanding of the technology alongside her existing pedagogical knowledge to science teaching.

Although the teacher had previously used an inquiry model of teaching and learning, the iPads presented new pedagogical challenges from the creation of routines for keeping the iPads charged and organized to transferring pedagogical practices, such as recording observations in experiments. Considering the use of Notability and iPads in the classroom, the teacher reflected on the process by saying,

> Finally, by October 25th I had the students type and write responses to pre-assessment questions on rocks in Notability right away! They also looked at samples of rocks and added their observations to their note in Notability with their questions. I had handouts from a Rock and Minerals workshop that I used for their Rocks labs, however I did use the iPads to take a picture of the worksheet to project it on the Smartboard to refer to it. This worked well because our school did not have Elmos. As they played the rock cycle game, they recorded the information on each dice into their Science notebooks, ugh, why not use the iPads? I did incorporate the iPads in a note I shared with them of 8 pictures of Sedimentary Rocks in which they needed to identify. (6th GRADE Reflective Notes, n.d.)

This quote demonstrates how the use of the iPad and Notability played a role in pedagogy, but also how the teacher struggled with using the technology in the classroom for other activities. As time passed, she increased her use of iPad- based writing activities instead of “paper” in the classroom.

Technological knowledge. At the beginning of the year, technological knowledge had a huge impact in the teacher’s integration and use of the iPads. Her lack of knowledge led her to have students create “paper” science journals. As her knowledge of the iPad grew, specifically her knowledge of the Notability App, she transferred the students to e-science journals, which included multiple texts (e.g. drawn images, photos, and written notes in single documents). In addition, her use of technology in the classroom increased with specific ways to support learners with on-the-spot activities separate from their “paper” science journals. This is reflected in the teacher’s actual use of technology via an observation during March of the same school year.

> The students are reading an article on the Iditarod website and responding to it on Edmodo right now. Samantha Says ‘This is fun, it's like we are texting’. And Ned says, ‘we don’t even have to talk to one another.’ The assignment is to reply on Edmodo to what they are reading in any way, but include any words that are unfamiliar to them. They can respond to a classmate's reply and help them out if they can to understand vocabulary. The article discusses the trail from Cripple and the lack of snow and the impact it is having on the mushers/dogs. We will be relating this to our biome essential question. (Email, March 6, 2013)

The use of Edmodo, another technological application, provides students with the ability to discuss the reading online and allows interaction between multiple students at one time rather than the limited contact in a small group via their "paper" journals. Understanding how to support learners using this type of technology demonstrates a possible switch in thinking from the earlier considerations of the teacher having a majority of work done in the usual manner.

In addition, the teacher found that she did not have to stand-alone and be the only teacher in the classroom when using and explaining how to implement technology. She notes, "even though we were having trouble with the whole Notability, sharing it with me whether to email it or Google drive. The whole process of doing that, the kids were like…It was a good process for the kids to work together because one always knows what to do. So someone would say I thought you would do this and someone else would say no you do this. So it is kind of like there is some good collaboration there. They did well with it" (iPad Meeting, September 19, 2013). Through the use of technology, the teacher's general knowledge of how to use the technology in discipline specific ways grew along with her knowledge of using the iPad in general. She also learned how to manage and address student knowledge of the technology.

Student knowledge. At the beginning of the implementation, the teacher believed that the students as digital natives would move seamlessly into the iPad use in her science classroom. Digital natives are considered as those that have been immersed in technology since they were of a young age and require a digitally and technologically enhanced learning environment in order to learn and prosper in and beyond their educational environment (Prensky, 2001). However, she soon learned that the students were not used to using the devices for learning. She learned that she needed to focus the students on how to search effectively and how to read images. There was a cadre of students who did understand the workings of the iPad, such as finger movements and button pushes. This was helpful for the management of device use on a daily basis. Although it did improve efficiency for classroom use, it did not guide students in learning from the iPad. Using the device for learning was something that needed to be taught.

One lesson included helping students to learn how to examine images to build scientific knowledge. The teacher reflects on this by noting the use of finding quality, Google images. She says,

> … I used one of the Google images to kind of teach to them why they are called the way they are and where they are and not. They had to look through the images and choose three and then they put it in Notability and they copied them into Notability and um ...this is mine (shows me hers). Because I told them that I wanted them to choose three that they understood, that made sense to them and that they could study from. And so then I thought, so here is mine. I have four here because I used some to teach other things. So here is the best one, these are all the parts I wanted them to learn. But this picture didn't work for some kids because of the three dimensional look. So, some of it worked better with this. We talked about the ....there are a couple of activities that we are going to do on oxygen and the clarity of the water next week; but um...but this one worked better for Paul because it had both sides of the lake. (Cindy Recording, May 6, 2014)

Students benefit from not only being shown how to find quality images, but also from understanding the processes underlying how to evaluate and determine if the images that enhances understanding. Both the teacher and the student had to go through a process of what was effective and useful when determining which image increased content knowledge and could be best used for studying. In addition, a discussion of the process and consideration of why some images worked better than others for some learners was beneficial as it allowed the students to practice digital and science disciplinary literacy skills. A final representation of how students used different images to build there knowledge is illustrated in Figure 2.

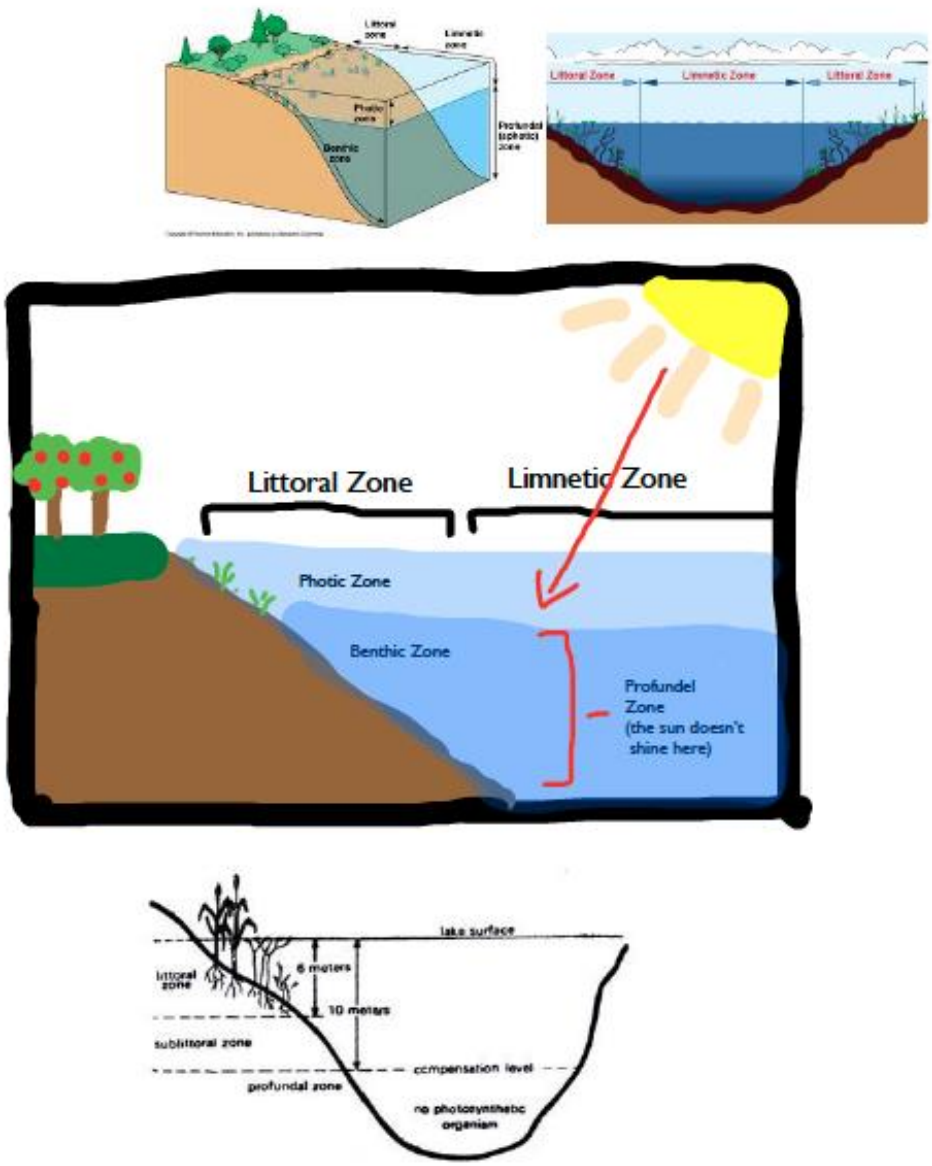

Figure 2. Zones of the Lake Ecosystem. Demonstration of various images.

Content Knowledge. At the start of the implementation, the focus of the weekly meetings was on pedagogy, technology, and students. As the teacher became more comfortable with iPads and disciplinary science literacy, the conversations shifted to illustrate her depth of content knowledge. These conversations began with a discussion of the content she needed to teach, an explanation of the content and what she hoped students to understand about the content. This discussion then moved to the best ways to have students illustrate their knowledge of the content using the iPad. This is reflected in the words of their teacher regarding use of the searches to support content knowledge, as well as why and how illustrations were chosen. She says,

> Doing some research and looking for a real picture of how you would see it under the microscope. Not a drawing, not an animated or whatever. A real photo and then I have this that I gave them copies of this {shows a plankton identification handout} at the microscope so that as they are looking they can see what they look like. Um, these are the ones that they will see. And then, what I would like to do is I would like to do one little activity though although it's not even in the course of study, I don't even care. To teach them about where these organisms are in the water as far as the zones of the Lake, you know. We dredged these up from the bottom and we learned the word benthic you know bottom layer and .... (Cindy Recording, April 29, 2014)

Although the use of paper handouts were still being used, the teacher is reflecting on having students use the Internet to find authentic photos of discipline specific words in order to increase content knowledge of the text. The teacher noted that the use of the Internet allowed her to go deeper on related materials in order for students to gain a more in-depth look at the content being covered.

The metacognitive teacher. During the course of iPad integration the teacher's metacognitive decision making increased. She made changes to her teaching to assure that objectives were being met. She offered suggestions for different ways students could address a problem. She reflected on how to use her knowledge of students, technology, content, and pedagogy to alter instruction. Additionally, the teacher's metacognitive teaching disposition was observed throughout the study as being affected by school factors (i.e., class interruptions due to schedule changes), student factors (i.e. knowledge of how to save work to Google drive), iPad factors (i.e., choosing the right app to meet curricular goals while considering student knowledge of the app and content and the pedagogical implications of the app), and curricular factors (i.e., the required curricular content), among other factors. The teacher reflects on this when considering her way of having students review school work by saying, "…28 years of paper and pencil. I still like thinking about how I can use the iPad. I am thinking more creatively; but I could have them do things like the section review instead of having them turn in their paper" (iPad Meeting, September 19, 2013). Connecting with not only the content, but being aware of the needs of the student with regard to what the students' needs are for future instruction makes the teacher note that the students, "couldn't hear my voice very well and we had to figure out the whole volume issue because there is a volume button in Notability and there is a volume button on the iPad. You know, there are all of these volume buttons to check out. So you know even .... I should have....next time I would go over some of those things, microphone, volume, with them" (Cindy Recording, April 29, 2014). She considers her own processes and understanding of technology needs when she says, “I am at the point where I ask myself, how can I do this activity using the iPads, or how can the students show me what they know using the iPad as a form of assessment? Have I used them too much with a group?” (Cindy iPad Reflection, November 14, 2013). Throughout the study, the teacher adjusted her teaching to the content, learning, and iPad use needs and her “metacognition served as a mechanism for problem finding, for setting adaptive goals, for identity building, and for value clarification” (Lin, Schwartz & Hatano, 2005, p. 249).

The SAMR Model: Looking at the degree of integration

In this section, data analysis and results are presented by using the SAMR model lens. The data demonstrates that the teacher was using the technology for enhancement and transformation.

In the fall, the teacher used the iPads mostly to modify traditional paper and pencil tasks. For instance, the students used iMovie to record a demonstration and explanation of surface tension and the teacher used Notability to have students insert images of animals with symbiotic relationships. She also used the iPad to augment traditional paper and pencil tasks when she chose to use the Notability app for learners to draw diagrams of mealworms; additionally, she used Quizlet to practice vocabulary, writing summary of notes on atoms and molecules in Notability, and shared responses to questions using Google Drive.

After a semester of using the devices, iPad use became more varied. There was evidence of substitution when students typed observations from their experiments using Notability. Yet, pure substitution of tasks was more often replaced by augmentation as evidenced in how this teacher had her students use Notability to type questions they had on praying mantises, and then used the Internet to research answers; hen she asked students to use the Internet to partner read, type notes in Notability, and watch video on biomes from the Internet; and by regularly having students use Notability to record lab notes. Lab notes included images and diagrams taken and created with the iPad. The teacher continued to modify her teaching using the affordances of the iPad as evidence of students' use of Edmodo to respond to questions comparing the Biomes of the Desert and Alaska, and to have an asynchronous discussion on the biomes and when students collaboratively answered questions about algal blooms in a new document in Google Drive. These tasks led to the teacher's use of the iPad to redesign how she used Notability as a multimodal science journal by having students read over their notes in Notability on waves, then asking students to draw waves into Notability note, and label the parts of the waves. Once this part of the project was complete, learners attached images from the web to illustrate key ideas and then the teacher used images of the posters taken on a field trip to a lake to help students identify organisms under microscope from the sample brought back from trip. Students typed notes in Notability to insert images of plankton and to demonstrate their understanding of the content.

The analysis of the data through the lens of the SAMR model not only showed how the level of integration, but it demonstrated how implementation changed over the course of the year. These changes occurred as the teacher was engaging in metacognitive teaching using her knowledge of students, content, pedagogy, and technology to influence her decision making process. As her knowledge changed so did the decisions she made about how to implement instruction; over time, data showed that technology changed her instruction.

Discussion

This research examined a 5th through 8th grade science teacher's disciplinary literacy instruction using iPads through the lens of the M-TPACK framework and the SAMR model. This research used multiple classroom observations, interviews with the teacher, and review of classroom artifacts to provide descriptions of how the M-TPACK (Wilson, Zygouris-Coe, Cardullo, & Fong, 2013) and the SAMR (Puentedura, 2006) models can be used to describe how iPad use for academic purposes transforms teaching and learning. This teacher adapted her instruction to assure that students gained the digital literacy necessary to be successful with the iPads, while at the same time she used it to develop their science knowledge. Sometimes the change in instruction was simple; for instance, using Notability to share class notes with the students so that students could add to those notes). Sometimes it was more complex; for instance, having students use Edmodo to engage in asynchronous discussions about science content. The moves made by the teacher were almost entirely in response to the integration of the iPad into the classroom and her focus on disciplinary science literacy.

It is evident from the data that the teacher monitored students' progress, her curriculum goals, the effectiveness of pedagogy, and the use of technology to make metacognitive instructional decisions, the curriculum goals, the effectiveness of pedagogy, and technology to make metacognitive instructional decisions. Specifically, the teacher addressed the role of technology, the iPad and applications, her planning, and all it entails in order to support her students' progress and her instruction. She questions herself early on asking, "how can I do this activity using the iPads, or how can the students show me what they know using the iPad as a form of assessment?" (Cindy iPad Reflection, November 14, 2013). She considered the role of technology and was inquisitive on exactly why things are changing when saying, "…they are just practicing. They were less asking me questions on how to do it. They were just in it. I am going to figure this out. It is just the nature of the group. They were more willing to experiment. They thought it was fun and exciting and whatever" (Audio 5_22_14, May 22, 2014). These actions demonstrated that it is through the integration of all areas of knowledge that the teacher made metacognitive decisions that led to instructional adaptations and integration of the iPad to promote students' science (and technology) learning. These practices showed evidence of a metacognitive teacher who recognized the need to adapt instruction with the implementation of new technology and moved beyond using the technology as a substitute for paper and pencil tasks.

The nature of the study's research design and the use of a convenience sampling (Salkind, 2010) have inherent methodological limitations. The research design allows us to examine a new phenomenon (i.e., iPad integration in a science classroom for academic purposes). Results from the convenient sample (Kemper, Stringfield, & Teddlie, 2003) cannot account for generalization, adequate representation, and replication. Built-in bias and validity were addressed through triangulation and constant comparison methods. Although generalizability of findings is limited to the participating sample, both the M-TPACK (Wilson, Zygouris-Coe, Cardullo, & Fong, 2013) and SAMR (Puentedura, 2006) frameworks could be used as lenses for analyzing the role of technology integration in teacher and student content, literacy, and learning practices.

Educational Significance:

Researchers in digital literacies (Leu, Kinzer, Coiro, Castek, Henry, 2013; Coiro & Dobler, 2007; Lankshear & Knobel, 2003) recognize that the spaces in which we construct literacy are evolving. Findings from this research indicate that the advent of new literacies and the introduction of an iPad for academic learning have forged new cognitive monitoring issues for teachers (i.e., new technologies, new formats, new content). Teachers must be able to allocate and monitor these cognitive resources and adjust their teaching. Teacher preparation and continuing education in technological literacy requires professional development dedicated to instruction on the use of multimedia devices, such as the iPad, for learning in the classroom. It also requires that the teacher's disposition as a metacognitive teacher be further explored for the purpose of identifying how to use these technologies to teach students the necessary content, literacy, and technological strategies and skills necessary for learning and college and career readiness.

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